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CREEP TEST DEVICE OF
CEA/SEMI/LECM

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ABSTRACT :

The LECM creep test machine is composed of six independant furnaces equipped with capacitive transducers and a pneumatic circuit.

This device may be used on PWR and FBR materials and for all the rod or pin geometries. That is the reason why the temperature range is relatively large (Tmax=900°C) and the furnace conception is flexible enough to permit adaptation to various geometries.

The device qualification has requied the calibration of the six furnaces, the pressure and the displacement transducers and the thermocouples. The following stage has consisted to test the measurement line.

Many blank tests have been performed on non irradiated materials, essentially to verify the furnace equivalence. No atypical comportment has been detected.

In order to evaluate the inflence of some parameters as sample length, we have performed a creep test campaign on non irradiated samples with different lengths.

An intercomparison campaign with two other laboratories (CEA/SRMA and EDF/EMA) has been performed on non irradiated tubes taken in homogeneous series. The very good fit between the three laboratories has permitted the tests on irradiated materials.

I INTRODUCTION

The LECM[1] (Laboratoire d'Etudes et de Caractérisation des Matériaux) located at CEA/Saclay studies the irradiated materials. One part of the Laboratory is especially devoted to mechanical testings. This Laboratory is included in the High Activity Laboratory on the CEA Saclay Center where are installed a series of hot cells (fig.**1**) giving a large possibility of mechanical characterization of irradiated materials.

We will describe hereafter the LECM creep test machine which has been implanted in a hot cell at the beginning of 1996.

II DESCRIPTION

The LECM creep test machine is composed of six independant furnaces implanted in the same cell (fig.**2**). This number has been chosen because each test has to be tripled due to the intrinsic experimental dispersion that may be encountered for this type of test even on homogeneous samples.

As the materials come from different origins, it is necessary that the testing machines may be able to work for various geometries and operating conditions. That is why the LECM creep test machine may be used on PWR and FBR materials and in a relatively large temperature range (Tmin=200°C - Tmax=1000°C). The furnace conception is flexible enough to permit adaptation to various geometries.

Each furnace (fig.**3**) comprises three independant heating zones. Each one is constituted of a resistance in Kanthal A1 equipped with Chromel-Alumel thermocouple connected to an EUROTHERM® regulator. This furnace conception permits us to assure a thermal gradient less than 1°C around ± 25 mm here and there of the sample median part.

The test sample is pressurized with argon in order to obtain the stress according to the test specification. The mean circonferential stress is chosen as $\sigma = P\, D_m / 2\, e$, where D_m and e are respectively the mean diameter and the tube thickness before the test. No pressure or stress regulation is made during the test, but because of the small deformations waited on PWR samples (the tests are stopped before the ternary creep phase), we may approximate that creep tests realized

[1] Material Study and Characterisation Laboratory.

at constant gazeous volume are not significantly different from those realized at constant pressure or stress.

Because of the great thermal variation sensitivity of the creep test, the cell temperature is regulated at 35 ± 0.5 °C by heating the air coming from the ventilation.

Sample test preparation

Test sample is part of a cladding tube 120 mm long (fig.4), wich has been previously chemically removed if it comes from an irradiated fuel rod. This reference length has been experimentally determined in order to obtain the best compromise between the absence of end-effect perturbation and the minimum use of irradiated material. Some tests performed recently on Zircaloy 4 have shown that it is possible to use samples of 90 mm or 60 mm length. Nevertheless this later dimension makes the further operations difficult.

The zirconia layer is removed by mechanical cleaning on 15 mm at the both ends of the tube in order to permit a good clamping of the adaptator plugs. The risk of cracking due to low ductility can only be minimized by a 'soft' cleaning and a mechanical polishing of this cutting which prevents from crack initiation.

After this preparation, the samples are measured (diameter and thickness) in order to allow the best possible stress calculation.

A thermocouple is clipped on the sample just in order to measure the sample temperature. No regulation is made from this thermocouple.

As the sample may be from different lengths, an extension piece is connected to the sample bottom plug in order to assure that the displacement probes are located on the sample median part.

Test operation mode and data processing

After its preparation the sample is connected to the pressure system part and is put into the furnace already at the test temperature. The deformation probes are put in contact of the sample. The test begins after thermal stabilisation (about 1 hour) of the whole system. During the test, a compatible PC-computer records : displacement (two probes by sample), pressure (one gauge by sample), sample temperature (one TC by sample), cell and under-cell temperatures. We have developped a programme under LABVIEW® that permits to follow and visualize all these parameters during the test. In order to avoid too large files, the acquisition is piloted either by displacement (primary and ternary creeps) or by time (secondary creep).

As an example the figure **5** shows the parameter evolution during a creep test at 400°C and 130 MPa on an irradiated Zicaloy sample.

III CONCLUSION

The qualification of the device implanted in the hot laboratory against two others implanted in 'cold' laboratories (EDF and CEA) has insured the quality of the results.

After less than one year of utilization, we have successfully tested more than 80 irradiated Zircaloy samples.

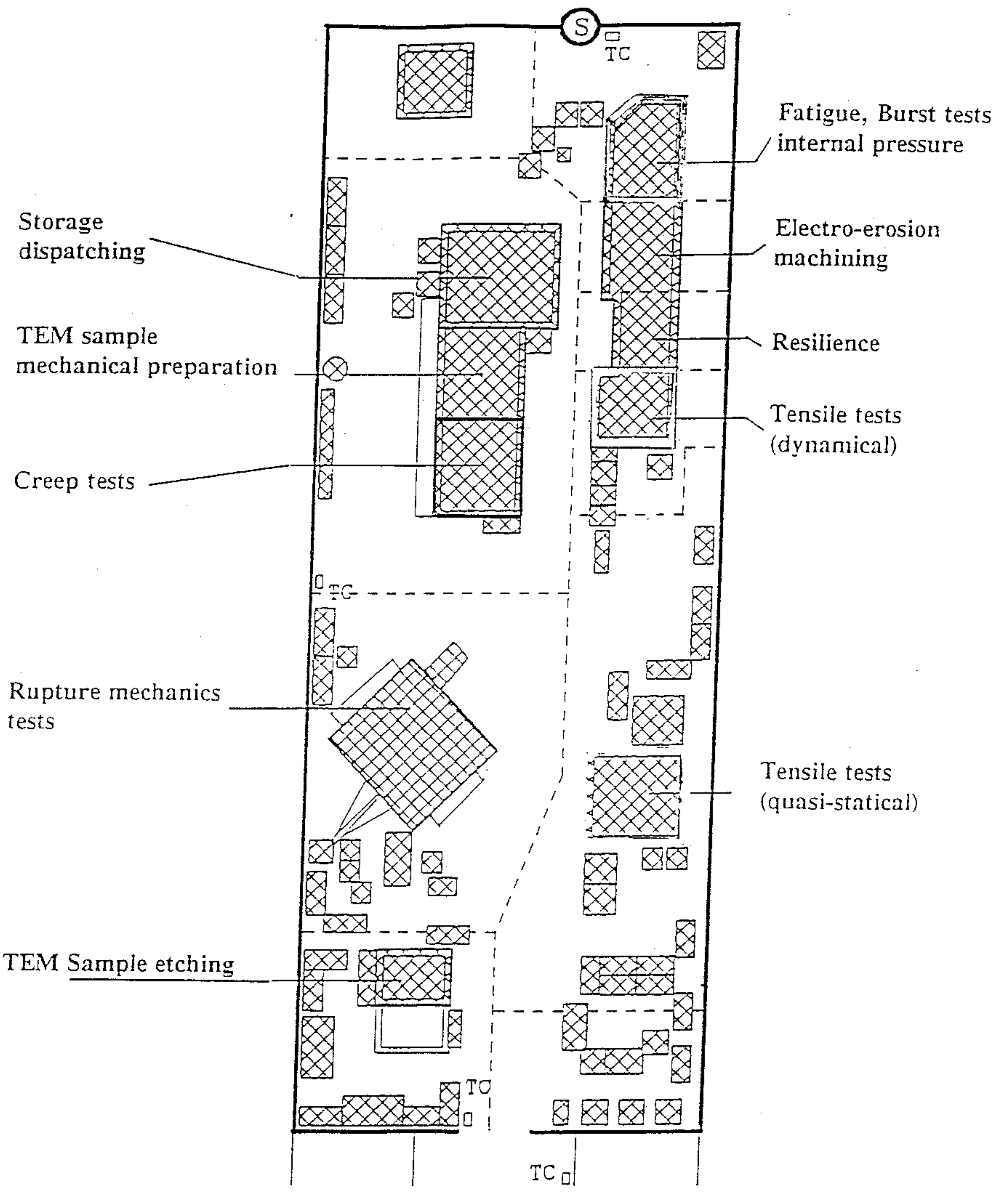

Figure 1: The Saclay mechanical test facility for irradiated materials

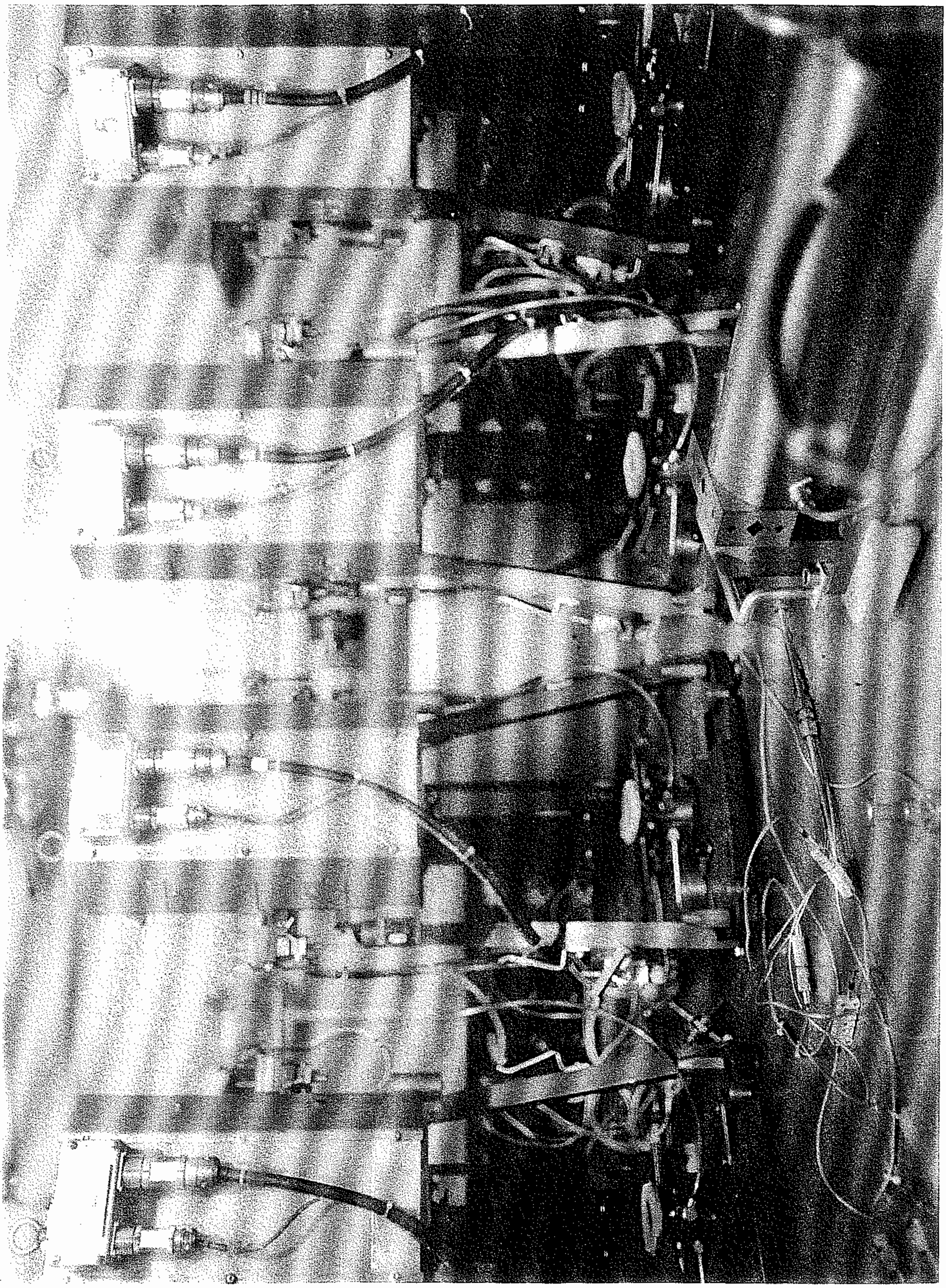

Figure 2 : Creep test device.

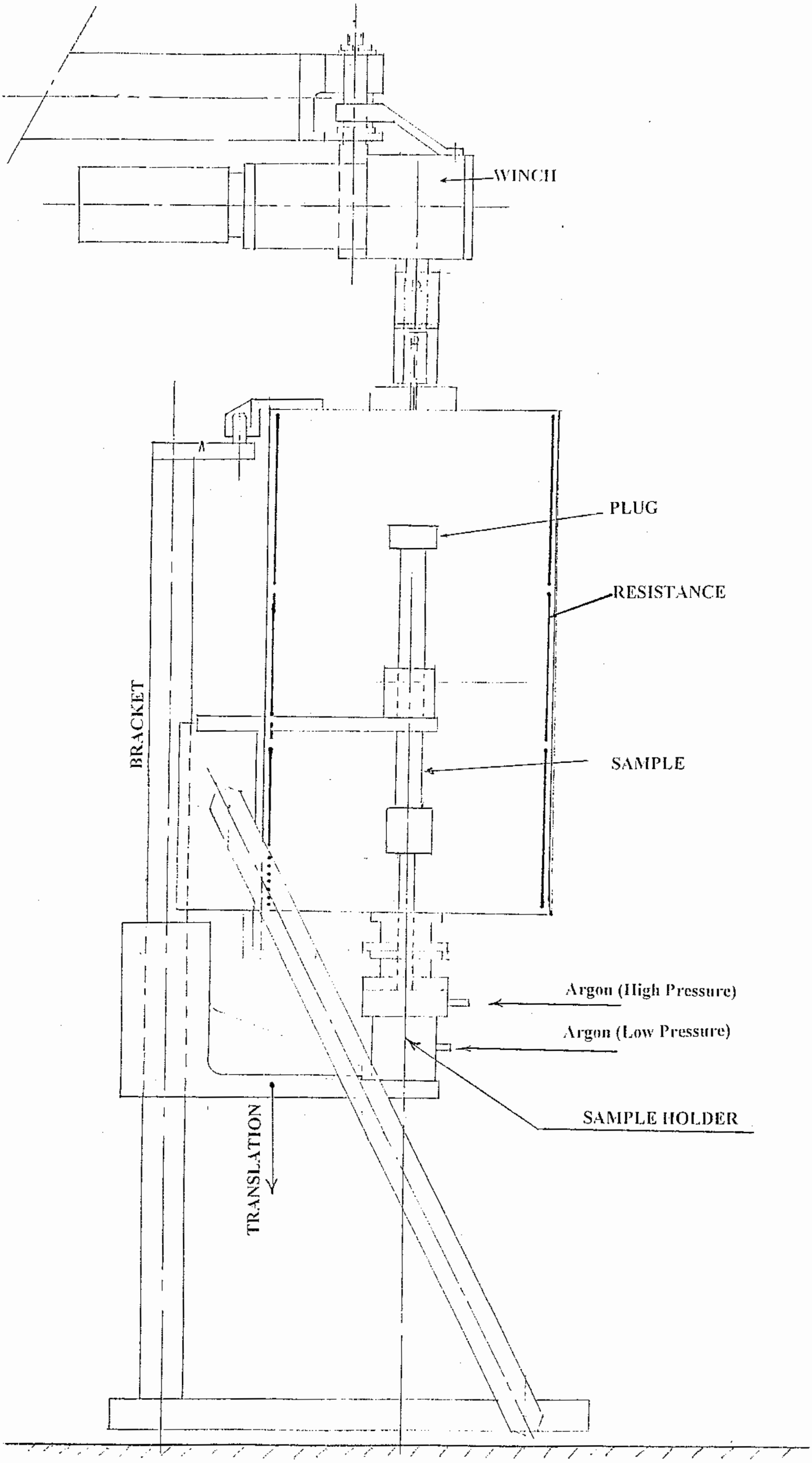

Figure 3 : Furnace

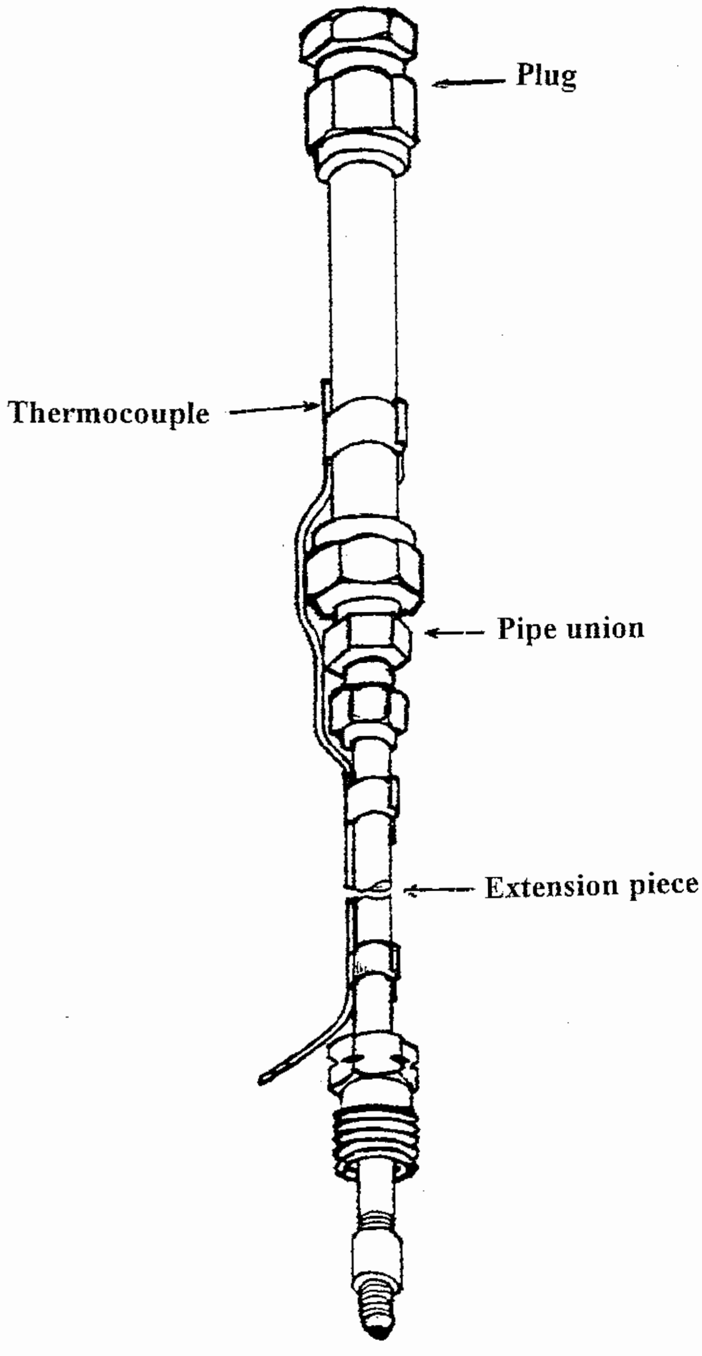

Figure 4 : Creep test sample

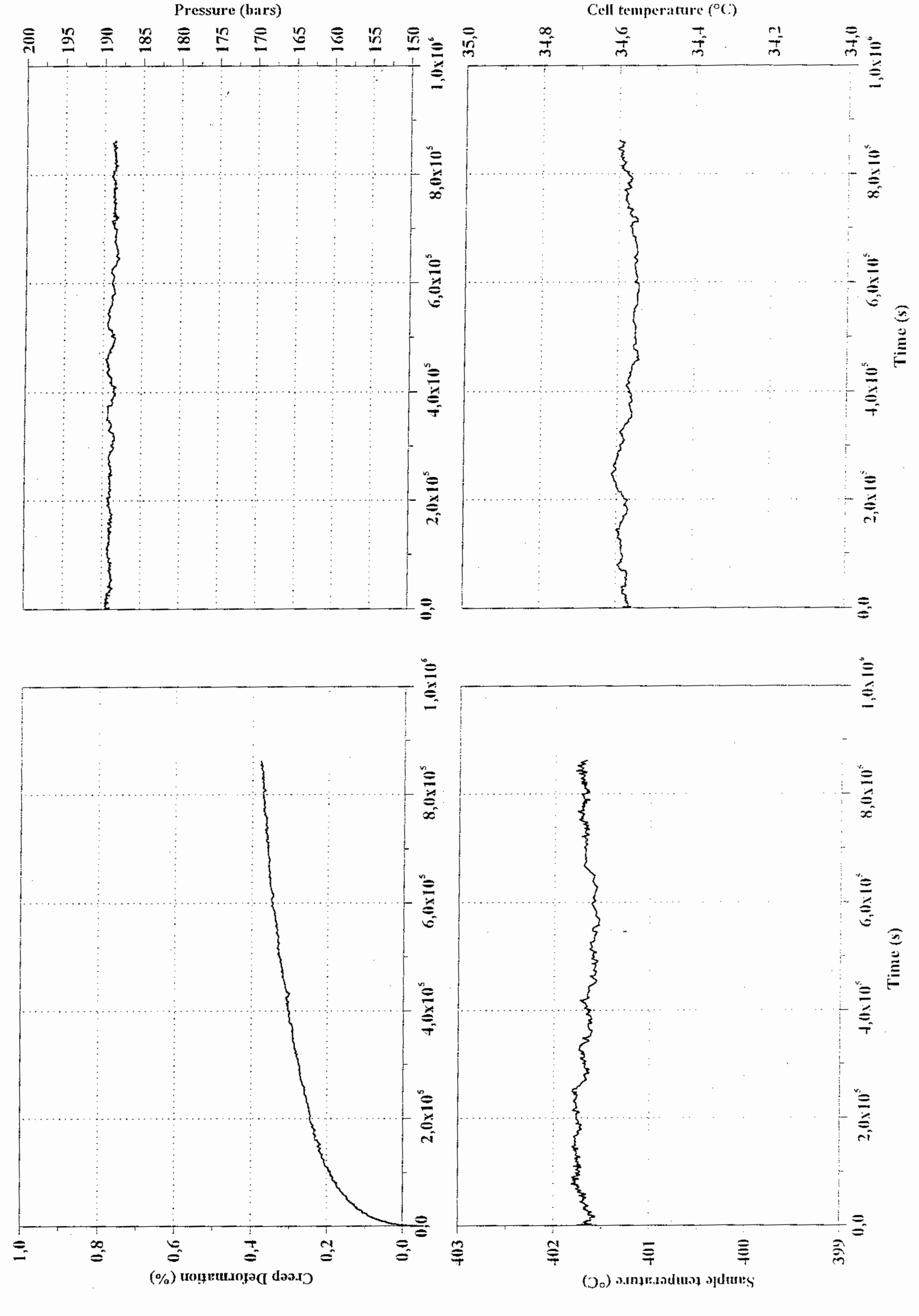

Figure 5: Parameter evolution during a test